The dilemma of lifting in deep waters

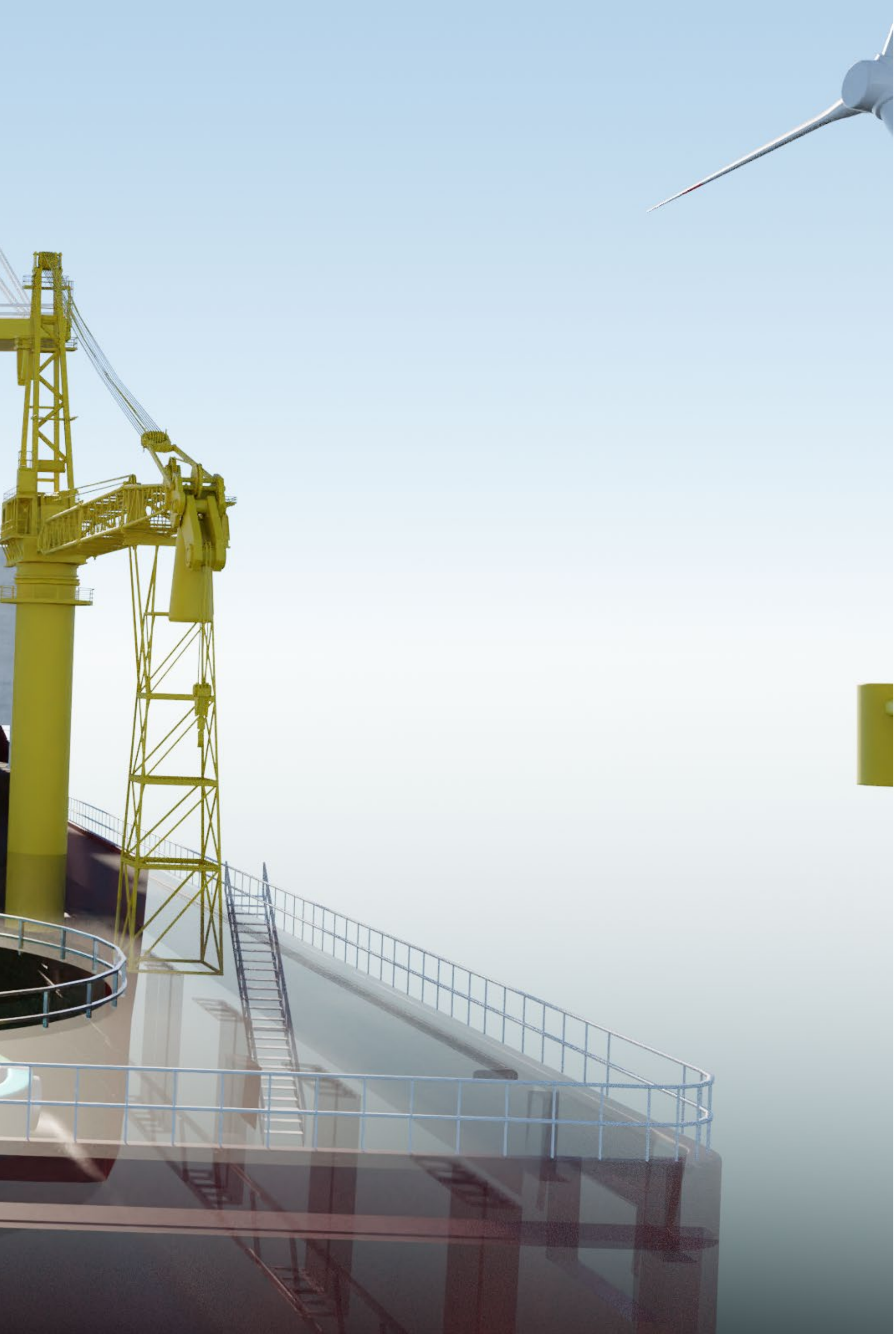
The seemingly never ending ramp up in offshore wind installations in recent years, together with the drive for ever larger and heavier wind turbines in deeper waters, presents the industry with many logistical challenges. Not least of these is heavy lifting operations in deep waters.

The next generation of turbines, up to 20 MW, are likely to have nacelle weights upwards of 600 t, mounted on the top of towers with heights of over 160 m and with rotor diameters exceeding 265 m. The assembly of these machines will be a mammoth undertaking, however it is achieved. Despite the recent developments of XXXL monopiles, in water depths of over 80 m it is most likely that these machines will be mounted on floating foundations. Many existing proposals intend to carry out the machine's assembly at a quayside or facility close to shore, but without towing the floater back to port any major component replacement will still require an offshore crane.

Aside from the challenge created by the huge loads and heights that would be required for a crane, the problem is compounded when performing such lifting operations in deep waters, due to the constant heave, pitch, and roll motions of the sea.

Most crane vessels currently used for wind turbine installation are of the jack-up type. These have a large crane mounted on their deck and are equipped with large legs that are lowered down to the seabed to lift the whole vessel out of the water, creating a stable platform from which to perform lifting operations.

However, the most recently built jack-up vessels are now stretching their technical and financial viability, yet are restricted to operations in water depths of less than 60 m to 80 m. Some of the latest vessels are equipped with cranes that have



lifting capacities in excess of 3,000 t and jib heights of 162 m and as such are well positioned for the installation of next generation turbines in water depths of 80 m or less.

Despite the progress in jack-up technology, there is still a shortage of these ships to cover the existing and future demand for offshore wind farm operations, and there are far fewer options when it comes to moving into deeper waters.

One such option is the use of a large shear-leg floating crane, but although most of these easily have the weight lifting capacity, not many have the under hook height required. Most are also based on a flat-bottomed barge, so they have limited stability in anything more than moderate sea states.

Another option might be to use one of the supper large semi-submersible crane vessels, such as the SSCV Sleipnir, the Saipem 7000 or the SSCV Thialf. These vessels could lift the whole wind turbine in one go and due to their design, are usually very stable, even in higher sea states. However, there are no more than a handful of these vessels in existence and with lifting capacities ranging from 7,000 t to 20,000 t and price tags of around $1 billion, they might be viewed as using a sledgehammer to crack a nut.

There are other technologies emerging that aim to overcome the challenge of sea motions and lifting in deep water. These include small cranes mounted on motion compensated platforms, under hook motion compensators and rapid ballast compensation pump systems.

The motion compensated platforms act like an aircraft simulator, where the operating platform is mounted on a set of rapidly responding hydraulic legs. Sensors, a computer controller, and high-powered hydraulic pumps monitor the movement of the host vessel and rapidly extend or retract the legs of the platform, to maintain its stability in relation to the motion of the vessel's hull. These systems are complex, could be problematic and are limited in their lifting capacity and reach.

Under hook motion compensator devices are being developed by a few companies active in the offshore industry. These devices are generally based on a large spring arrangement, or a sprung loaded scissor type device, and cushion or compensate for the heavy motion of the vessel. Some of these have now been tested to lifting capacities of up to 2,000 t. They don't, however, compensate for the pitch or rolling motion of the vessel, which can be highly accentuated over the lifting height of the crane.

Some newly developed vessels use high powered water pumps to move water ballast around in tanks within the vessel's hull. These have proven quite effective, by counterbalancing the lift weight with ballast in the hull. However, having water ballast acting as motion compensation, the crane operation will still be affected by sea state, albeit to a lesser degree, and the consequences of a hook, cable or pump failure could be catastrophic.

What could be the solution? A British start-up company, Innovative Offshore Developments Ltd (IOD), has a patent pending concept for a new type of floating offshore heavy lift crane vessel, for use in deep waters.

The idea, together with a few spin-offs relating to floating turbine foundations and supply vessels, uses a number of known and well proven marine engineering principles. Specifically, these are a floating spar, a telescope, a moonpool and a gimbal.

Spar type platforms and buoys are well known in the marine industry, particularly in their use for oil and gas platforms. They are generally tubular structures with a deep draft, which are ballasted at the bottom, like an iceberg, or a long fishing float. They are inherently stable due to their high buoyancy, whilst retaining a low centre of gravity, giving them a positive Metacentric Height. This is the theoretical intersection point between the upward buoyancy force line and the lines of buoyancy force created by the roll and pitch of the hull.

Historically, due to their deep draft, they have been constructed and deployed on their sides. Once in deep enough water, the bottom end is flooded and ballasted to upend the structure before any equipment is installed on top and the whole structure towed to its final mooring position.

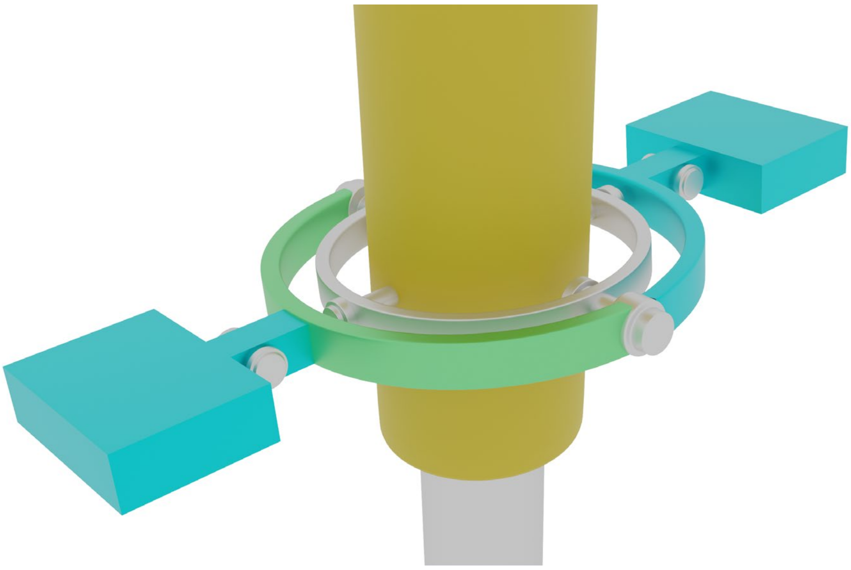
The new crane concept uses a spar to support its crane, but its structure is telescopic and when not in use, or when entering shallow waters, it is retracted up to the underside of the hull of the vessel and into the supporting column of the crane.

The telescopic spar and column of the crane are supported through a moonpool in the vessel's hull, via a Gimbal frame, which is a number of concentric rings connected together via pinion points that oppose each other in each graduation of ring size, like the supporting frame of a ships compass.

The spar column is supported by the innermost ring of the Gimbal, whilst the outermost ring is split vertically into two halves, but share common pinion points. Each of these outermost half rings has a beam protruding from it at a 90° angle to the pinion points, which extends via a fulcrum point, through the side of the Moonpool wall and attaches to a counterweight, below deck, within the void of the vessel's hull.

When the crane is not in use and the vessel needs to enter harbour, the crane jib is lowered, the spar is retracted and the gimbal frame locked. This provides a shallow draft, enabling free movement of the vessel in and out of port and shallow waters.

When the crane goes into operation, the spar is extended, the gimbal frame unlocked and the crane jib raised. Once the spar ballast has been adjusted for the sea state and lifting conditions, the gimbal frame connection allows for the free movement of the vessel, roll and pitch, separate to that of the spar, whilst the counterweighted split outer ring, compensates for the vessel's heave motions.



IOD was set up in 2021 to develop and exploit this novel conceptual design of motion resistant, heavy lift, deep water crane vessel, together with the other spin off concepts. It has been working closely with the Department of Naval Architecture, Ocean & Marine Engineering at the University of Strathclyde. Utilising funding from Innovate UK, it has completed a number of initial scoping, sizing, hydrostatic and hydrodynamic studies, with favourable results. These studies help demonstrate both the concepts feasibility and scalability.

The next stage of development will require further detailed design and tank testing of a model, before a FOK prototype can be built and tested.

Considerable resources will be needed, as well as a presence in the market to develop and ultimately commercialise the designs, although with the already high and increasing demand for deep water lifting vessels, it could offer huge benefits. The plan is to attract a corporate or industrial partner, which does have the necessary resources and market presence to complete the development and provide a route to market. IOD would then plan to licence the manufacture of the vessels to one or more manufacturing partners.

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